A DISSERTATION ON THE MAGNITUDE OF THE YEAR.

[Price One Shilling.]


AUG
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BRITISH MUSEUM

A

DISSERTATION

ON THE

MAGNITUDE

OF THE

YEAR:

CONTAINING

An HISTORICAL ACCOUNT of TIME, from the earlieſt Ages down to the preſent;

The Method practiſed by the Ancients, for aſcertaining the true Meaſure and Magnitude of the Year, explained; and the Reſult of their Calculations compared, from a Table of the Magnitudes of the Years, Siderial as well as Tropical, calculated by the moſt eminent Aſtronomers, both ancient and modern; the Inſtruments uſed by the Ancients, for that Purpoſe, explained; and the Errors incurred by *Julius Cæſar* and Pope *Gregory*'s Method clearly pointed out.

ALSO,

A Method laid down, from the true Magnitude of the Year, given in Days, Hours, Minutes, and Seconds, to adapt the Calculation of Time to common Uſe, in ſuch a Manner, that there will neither be gained nor loſt, on true Time, one Second, to the lateſt Ages; which is clearly demonſtrated from the ſimpleſt Principles.

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TO

THE RIGHT HONOURABLE

PHILIP

EARL of CHESTERFIELD.

MY LORD,

AS your Lordſhip was a principal Promoter of the Bill for introducing the *New Stile*, and as this little Tract owes its Birth to that Event, it naturally falls under your Lordſhip's Protection and Patronage, ſo it is needleſs to trouble you, My Lord, with a tedious Apology for this Addreſs.

If your Lordſhip ſhall find any thing in this Performace worthy your

Notice, it will not only afford me a great deal of Pleaſure, to have merited the Approbation of ſo diſtinguiſhed a Judge, but, at the ſame time, procure it a favourable Reception with the Public.

The World, perhaps, My Lord, may expect that I ſhould entertain them with an Account of your Lordſhip's Abilities, as a Stateſman and eminent Patriot, &c. but this is too elevated a Subject for me, and ſo I ſhall leave it to thoſe who are better qualified to do Juſtice to ſo arduous a Taſk; and, without farther tranſgreſſing upon your Lordſhip's Patience, ſhall only beg to be indulged the Honour of adding, That I am, with the higheſt Eſteem,

MY LORD,

Your LORDSHIP'S

Moſt obedient,

and moſt devoted,

humble Servant,

The Author.

PREFACE.

THE following Performance being only designed, by the Author, to explain the Method practiſed by the Ancients, for meaſuring of Time; he did not think it neceſſary to treat of the moveable Feaſts, as that is already done at large by others: But as ſome Things mentioned here hath not been taken notice of by any Author whatever, he reckoned it would not be altogether unacceptable to the Public, though, at firſt, only intended for his own Satisfaction and Amuſement.

PREFACE.

The Reader will be pleaſed to correct the following Errors, which have eſcaped in the Preſs.

Page 6, Line 27, for 112, read 712.
17, Line 3, for *Conen*, read *Conon*.
21, Line 15, for *Eratoſtenes*, read *Eratoſthenes*.
22, Line 12, for *Paralux*, read *Parallax*.
25, Line 5, for *Bithian*, read *Bithinian*.
Ib. Line 11, for *Iſacius*, read *Iſaacius*.
26, Line 11, for *Perbachius*, read *Purbachius*.

		D.	H.	M.	S.	T.
Ib. Line 19, in the Table, for		375.	5.	55.	37.	40.
read		365.	5.	55.	37.	40.

Ib. Line 33, for *Danter*, read *Dantes*.

		D.	H.	M.	S.
28, Line 18, for - - - -		365.	5.	49.	57.
read - - - -		365.	5.	48.	57.

30, Line 6, for 5, read 5 *Sec.*
31, Line 18, for *ſetting*, read *ſettling*.
32, Line 10, for 668, read 663.
35, Line 7, for *determine*, read *determine*.
37, Line 18, for *Ricioli*, read *Riccioli*.
43, Line 26, for *Common*, read *Leap*.

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DISSERTATION

ON THE

Magnitude of the YEAR, &c.

SINCE, not only Men of the moſt diſtinguiſh'd Learning and Abilities, have, in the earlieſt Ages, exerted themſelves with uncommon Aſſiduity, but even Kings and Princes have uſed their utmoſt Endeavours, to determine and ſettle the true Magnitude of the Year, in order to adapt it to common Uſe, being convinced that an exact Computation of Time was of the greateſt Importance to Society; we ſhall therefore endeavour to ſtate in atrue Light, the ſeveral Steps that have been made towards it by the Learned in different Ages, together with the various Methods of computing Time in different Countries from the earlieſt Calculation down to the lateſt; and, at the ſame time, compare the one

with the other, and point out the Errors conſequential to the miſtaking the true Magnitude of the Year. And to render *the* Subject as clear as poſſible, we ſhall in the *firſt* Place give an hiſtorical Account of the Menſuration of Time as far back as we can trace it, either from ſacred or profane Hiſtory. In the *next* Place, for the Satisfaction of the Curious, we ſhall explain the Methods practiſed by the Ancients for diſcovering the true Magnitude of the Year, together with the Inſtruments whereby they made their Obſervations according to *Ptolomy*'s Account of them; this we never met with in any *Engliſh* Author. And, *laſtly*, we ſhall compare the *Julian* and *Gregorian* Stiles, point out the Errors of each, and lay down a Method for adjuſting Time in ſuch a Manner, as never to gain or loſe one Second to the lateſt Ages; and this we ſhall clearly demonſtrate from the ſimpleſt Principles, ſo as to render it obvious to the meaneſt Capacity.

The Neceſſity of meaſuring Time with Exactneſs and Preciſion, and the Advantages ariſing from it, ſeems to be early foreſeen; but the Defects of Aſtronomical Inſtruments and other Diſadvantages rendered the Taſk extremely difficult to thoſe who attempted it, as ſhall be ſhewn in its proper Place.

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The firſt who takes any Notice of the Diviſion of the Year is *Joſephus*, the *Jewiſh* Antiquary, who informs us, in his firſt and fourth Books, that the *Hebrews* divided the Year into Twelve Months before the Flood, and from *Herodotus* it is evident that the *Egyptians* made this Diviſion very early; nay, both he and *Clemens Alexandrinus*, notwithſtanding of *Joſephus*, aſcribe the Honour of dividing the Year in this Manner entirely to the *Egyptians*; They aſſert, that the *Egyptians* diſcovered its Magnitude, by the Motions and Revolutions of the Stars, to conſiſt of Three hundred and Sixty-five Days, and ſo made each Month to contain Thirty Days, adding the Five odd Days to the End of each Year as intercalary Days belonging to no particular Month. 'Tis true, *Diodorus Siculus* aſcribes this Diſcovery to the *Thebans*; but this rather ſtrengthens than diminiſhes the Authority of *Herodotus* and *Alexandrinus*, ſince the City of *Thebes* in *Greece* was peopled by a Colony from *Thebes* in *Egypt*, and he has left us in the Dark which of the two he means. But *Diogenes Laertius* affords us further Light into this Affair, when he informs us, that *Thales*, who travelled into *Egypt*, in order to ſtudy Aſtronomy, and improve himſelf in other Parts of *Mathematical Learning*, upon his Return made the Year to conſiſt of Three hundred and Sixty-five Days, which he divided into Twelve

Months intercalating the odd Days at the End of each *Year* in the ſame Manner as was practiced in *Egypt*; from whence he tranſlated this Method of dividing *Time* as well as all other Parts of *Mathematical* Knowledge into *Greece*. From what has been obſerved, it is obvions that little Credit is to be given to the Authority of *Servius*, who aſcribes the Diſcovery of the Magnitude of the *Year* and its Diviſion into Twelve Months to *Eudoxus*; adding, that it was afterwards more accurately calculated by *Hipparchus*, and laſtly by *Julius Cæſar*. For *Eudoxus* only flouriſh'd 360 Years before the Chriſtian Æra, but *Thales* 620. 'Tis true, the *Grecians*, before *Thales*, made their common Year to conſiſt of 354 Days or 12 Lunar Months, each containing 29 and 30 Days alternately, and every third Year they intercalated a whole Month, conſiſting of 30 days, which occaſioned *Thales* to prefer the *Egyptian* Method, and introduce the Practice thereof into *Greece*.

Having thus far trac'd the Method of computing Time, and given an Hiſtorical Account of it amongſt the ancient *Egyptians* and *Grecians*, let us next proceed to the *Romans*. *Plutarch*, in his Life of *Numa Pampilius*, informs us that *Romulus*, only divided the Year into 10 Months, conſiſting of very unequal Numbers of Days, ſome containing 35, and others only 23. What Number of Days he ſuppoſed

poſed the Year to conſiſt of, we can only diſcover by the Number of Days added to it by *Numa Pampilius*. He began his Year with the Month of *March*, which he ordered ſhould conſiſt of 34 Days; it was named *March* in Honour of *Mars* his ſuppoſed Grandfather; the Second he named *April* from the *Greek* Word ἀφρός, ſignifying the Foam of the Sea, which gave Birth to *Venus* the Mother of *Æneas*. The Third he called *Majus*, which according to *Fulvius in Faſtis Romuli*, was from *Majores* his Anceſtors. The Fourth he called *Junius* from *Juventus*, ſignifying Youth, and having in this Manner named the Four preceding Months, he named the Reſt numerically in their natural Order: The 5th he called *Quintilis*, which afterwards, in honour of *Julius Cæſar* was named *Julius*: The 6th *Sextilis*, which was afterwards called *Auguſtus*, in honour of *Auguſtus Cæſar*: The 7th was called *September*: The 8th, 9th, 10th, were called *October*, *November*, *December*. But this Method of meaſuring Time has no Conformity either to the Motion of Sun or Moon. *Numa* added firſt 50 Days to *Romulus*'s Year, and ſometime after 6 more: Six of the Months he made to conſiſt of 30 Days each, calling them *Menſes cavos*, becauſe they contained a Day leſs than the Four other Months, which were called *Menſes plenos*. The 56 additional Days he divided into Two Months,

Months, calling the first *January* from *Janus*, the most ancient King of *Italy*, who received *Saturn* after he was expelled by his Son *Jupiter*, and gave him a part of his Kingdom. The second he called *Februarius* from *Febrio*, which signifies purging of Souls; because in *Numa*'s Time, this being the last Month of the Year, the *Roman* People were accustomed to purge their Souls by Sacrifices the last Month of the Year; and hence it appears that *Numa* was the first that divided the Year into Twelve Months, according to *Plutarch*. But the Religion or rather Superstition that prevailed at *Rome*, creating a Veneration amongst the *Romans* for odd Numbers, this pious King after dividing the Year as above related, ordered that all the Months of the Year should consist of an odd Number of Days except *February*, which he made only 28: And hence *January*, *April*, *June*, *Sextilis* now *August*, *September*, *November*, and *December*, contained 29 Days; But *March*, *May*, *Quintilis* now *June*, and *October*, consisted of 31 Days. These are all the Regulations, with Regard to the Mensuration of Time establish'd by *N. Pompilius* the IId. King of *Rome*, who began his Reign 112 Years before the Christian Æra; and according to this Account his Year consisted only of 355 Days, which occasioned the *Romans* thereafter, in Imitation of the *Greeks*, sometimes to intercalate a Month

Month every third Year, and at other Times, they only intercalated ninety Days, or three Months of thirty Days each in eight Years: And when ſuch Intercalation was made, publick Notice thereof was given to the People by the High Prieſt according to the *Roman* Law. But as theſe Intercalations were not regular, the High Prieſts intercalating ſometimes a greater and ſometimes a leſſer Number of Days than they ought, and that always in Proportion to the Friendſhip that ſubſiſted between the Magiſtrates, the Publicans, *&c.* and them, it happened from their inaccurate Method of keeping the Kalendar; that in *Cæſar*'s Time, the firſt of the Kalends of *January*, or firſt Day of *January*, had fallen backward to the Kalends of *November*, that is to the 23d Day of *October*. *Julius Cæſar* being High Prieſt, and obſerving what Confuſion this Method of meaſuring Time introduced, reſolved upon a Reformation of the Kalender; and in order to adjuſt it with the greater Exactneſs, he brought *Soſigines*, a noted Aſtronomer from *Alexandria*, to aſſiſt him in ſettling the true Magnitude of the tropical Year. That learned Man relying upon the Calculations of *Archimedes*, *Callipus*, and *Gemius*, made it to conſiſt of 365 Days 6 Hours. And as the Fraction of 6 Hours amounts to a whole Day in four Years, he ordered that every fourth Year ſhould conſiſt of 366 days, making the Month of *February*,

bruary, which was only 28 days in common Years, to consist of 29 every fourth Year in place of 28; and that their ordinary Method of reckoning the Days of the Month might meet with no Interruption by this intercalary Day, he ordered it to follow the 24th of *February*, which in their Method of Computing was the 6th of the Kalends of *March*, that day every fourth Year was twice reckon'd, and the Year from thence was called Bissextile from *bis Sextas Kalendas Martii*. All other Years were reckoned common Years consisting of 365 days. By this Method of reckoning the Magnitude of the tropical Year, we see that all Years divisible by Four, *viz.* 8, 12, 24, 32, 48, *&c.* are Leap Years, or Years consisting of 366 days: but all those that are not divisible by four, are common Years, 14, 22, 30, 42, *&c.* or Years consisting of 365 days. *Cæsar* having thus added 10 days to *Numa*'s Year, caused two of these additional days to be added to each of the following Months, *viz. January*, *August*, and *December*; which formerly consisted only of 29 days, but were now encreas'd to 31; to the other four Months, *viz. April*, *June*, *September* and *November*, being only 29 days each, he added one Day, and so made them 30 days. These were all the Alterations made by *Julius Cæsar* with respect to the Mensuration of Time, which was very considerable, since by the Intercalation of one Day in the Space of four Years,

Years, and adding 10 Days and ſix Hours to *Numa*'s Year, all the confuſed and irregular Intercalations were entirely cut off.

Though *Riccicoli* and *Bulialdus* were of opinion, that *Cæſar*'s Year would have been ſtill more perfect if *Soſigines* had not miſtaken the Sun's Entry into the Solſtitial Points.

Suetonius, *Appian* and *Pliny*, after deſcribing *Cæſars* Alterations of the Kalendar, allow him the Honour of being the firſt that accommodated the Meaſure of the Year to the apparent Motions of the Sun.

Cæſar began his Year on the firſt of the Kalends of *January*, which happened about 7 Days after the Winter Solſtice, and his Example was follow'd by the greateſt part of *Europe*, until Pope *Gregory* in the Year 1582, reſolv'd upon a new Reformation of the Kalendar, which in the ſequel we ſhall take notice of.

From the whole it is plain that the Year at firſt conſiſted of 365 Days, and was divided into 12 Months; if not by the *Hebrews*, according to *Joſephus*, *Polidore Virgil* and *Riccicoli*, who agree, that Aſtronomy, and the Method of Computing Time, was tranſlated from the *Hebrews* to the *Egyptians* 1950 Years before the Chriſtian Æra, and that the Year conſiſted of 365 Days and was by them divided into 12 Months; from the *Egyptians* to the *Chaldeans*, from the *Chaldeans* to the *Grecians*, and from the *Gre-*

cians to the *Romans:* At leaſt, 'tis clear from *Herodotus*, *Diodorus Siculus*, *Macrobius*, *&c.* that this Science was very early known in *Egypt*, and by its Aſſiſtance the *Egyptians* as early diſcover'd the Magnitude of the Year and divided it into twelve Months.

Therefore when *Diogenes Laertius* aſcribes this Diviſion to *Thales*, and *Suetonius*, *Appian* and *Pliny* to *Julius Cæſar*, they mean no more, but that they were the firſt in their reſpective Countries that meaſured the Year by the Motion of the Sun, and divided it into twelve Months; tho' this is an undoubted fact, we cannot from thence conclude, that either of them diſcovered the Year's Magnitude, or that either of them were the firſt that uſed the Diviſion of it into 12 Months.

For this would evidently contradict other Paſſages of the ſame Authors, relating to the ſame Men, ſince *Thales* only made that Alteration after his return from *Egypt* into *Greece*, where he had ſtudied Aſtronomy under the Prieſts of *Memphis*, and from them learned that Magnitude and Diviſion of the Year; ſo that inſtead of being the Inventer of this Method of meaſuring Time, *Thales* was only the firſt that introduced it into *Greece*, and undoubtedly *Diogenes Laertius* means no more, when he ſays, that *Thales* was the firſt who adapted the Year to the apparent Motion of

the

the Sun, computing its Magnitude to consist of 365 Days.

This Opinion is further confirmed from the *Olympiads*, each of which contain'd a Period of four Years, consisting of 12 Lunar Months, each containing 29 Days and one half.

This Method of computing Time was instituted by *Pelops* in Honour of *Jupiter*, about 1300 before the Christian Æra, and consequently 593 Years before *Numa*. 'Tis true these Olympiads were laid aside for some time, but were reviv'd by *Endymion*, *Nelius*, *Pelius*, and afterwards by *Lycurgus* 904 Years before our Saviour, and at last were fix'd by *Iphites* 774 Years before Christ, without any other Alteration than that made by *Thales* 154 Years after, who chang'd the Lunar to the *Egyptian* Solar Year, which consisted of three hundred and sixty-five Days.

Plutarch is to be understood in the same Sense with respect to *Numa*, *viz.* that he was only the first amongst the *Romans* that divided the Year into 12 Months.

Numa Pampilius began his Reign, according to *Helvicus*, in the 3d Year of the 16th Olympiad, or 712 Years before Christ; from which it is evident, that the Division of the Year into 12 Months was in use amongst the the *Grecians* 588 Years before his Time; so that I think 'tis past Dispute, that the *Hebrews* and *Egyptians* were not only the first that

divided the Year into 12 Months, but alſo the firſt that adapted its Magnitude to the Motion of the Sun, nor can there be any thing more abſurd than to aſcribe to *Numa*, *Thales*, or *Julius Cæſar* a thing that happened ſo long before any of them exiſted.

From this account of the Computations of time uſed by different Nations, it evidently appears that the Magnitude of the Year, was always meaſur'd by the apparent Revolution of the Sun, Moon or Stars, and ſometimes jointly by the Motions of both Sun and Moon.

Years computed by the apparent Motion of the Sun alone, are called *Solar Years*; and thoſe meaſured by the Motions of the Moon alone, are called *Lunar Years*, and by the Motions of both, *Luniſolar*. If they are meaſured by the Stars, they are called *Siderial Years*. Tho' theſe laſt mentioned Years have not been much in uſe, yet 'tis plain from *Herodotus* and *Polydore Virgil*, that the *Egyptians* diſcovered the Magnitude of the Year by the Courſe of the Stars. It is, indeed, probable that the Meaning of *Herodotus* in that Paſſage, is, that they diſcovered the Magnitude of the Year, from the Time that the Sun took up in moving from any one Star until he arrived at the ſame again; but ſtill that Interval of Time is allowed by all Aſtronomers to be the Meaſure of a Siderial Year. The Solar Year then is

divided

divided into Siderial and Tropical. The Tropical Year is, that Space of Time the Sun takes up in moving from one of the Tropicks or Solſticial Points until he return to the ſame.

This is what moſt Nations allow to be the Meaſure of the Civil Year. The *Egyptians*, *Chaldeans* and *Phœnicians*, after *Thales*, and ſome Time before him, uſed the Tropical Year; this is evident, ſince the Preceſſion of the Equinoxes was only diſcovered by *Hypparchus* 484 Years after *Thales*; from which Preceſſion ariſes the Difference betwixt the Siderial and Tropical Years.

The *Hebrews* and *Egyptians* we ſee very clearly uſed the Siderial Year long before that time, which was very natural in theſe early Ages of the World, it being much eaſier in the Infancy of Aſtronomy to obſerve the Interval of Time taken up by the Sun in moving from any one Star until he returned to the ſame, than to obſerve his Departure from any Point in the Eclíptick, and his Arrival at the ſame again.

Therefore, from the firſt time Mankind began to obſerve the Motions of the Sun and Moon, many hundred Years might paſs before Aſtronomers diſcovered there was ſuch a Thing as the Ecliptick; ſo that all Solar Years antecedent to the Diſcovery of the Ecliptick, as we have already obſerved, muſt have been Siderial Years; nor indeed is it quite certain, when the Ecliptick was

firſt

firſt obſerved, tho' we are ſufficiently ſatisfied that it was known to the *Egyptians* when *Thales* ſtudied at *Memphis*, ſince, upon his Return to *Greece* he altered the Meaſure of the Year from the Lunar to the Tropical Solar Year, which made *Diogenes* aſcribe the Diſcovery of the Tropicks and Equinoctial Points to him: But, altho' the Knowledge of the Ecliptick was introduced into *Greece* by *Thales*, yet it was very little underſtood amongſt the *Grecians* for more than a hundred Years after his Time, as is evident from *Theon Smyrneus* the Aſtronomer, who obſerves that *Eudemus* in his Hiſtory of Aſtrology aſcribes the Honour of diſcovering the Ecliptick to *Oenopides* of *Chios*, who liv'd, according to *Riccicoli*, 560 Years before the Chriſtian Æra, which was 60 Years after *Thales*. *Plutarch* afterwards aſcribes it to *Pythagoras*, and *Pliny* ſays, that *Anaximander* made the Diſcovery *anno ante Chriſt.* 520, which is no leſs than 100 Years after *Thales*; a plain Evidence of the ſlow Progreſs that Learning made in theſe Ages, and we may eaſily conclude, it advanced by ſtill ſlower Steps in Ages antecedent to the *Grecians*.

From the Inſtitution of the *Olympick* Games the *Grecians* uſed the Lunar year, to the Time of *Thales*, as is plain from its Magnitude being 354 Days or 12 Lunations, each conſiſting of 29 1-half Days. But *Thales* introduced the *Egyptian*

Egyptian ſolar year conſiſting of 365, and conſequently after his Time the tropical ſolar year was always in uſe amongſt the *Grecians*.

Before *Hypparchus*, the Solar and Siderial Years were ſuppos'd the ſame, as we learn from *Ptolemy*, *Riccicoli*, *&c.* who agree that he was the firſt that obſerved the Preceſſion of the Equinoxes, and that from thence a difference muſt ariſe betwixt the tropical and ſiderial years, which, in all Probability was never known to his Predeceſſors.

The Year in uſe amongſt the *Romans*, in the Time of *Romulus* was ſo irregular, that we can hardly aſſign it any Name, it being neither Solar, Lunar nor Luniſolar, as is clear from *Plutarch* and *Polidore Virgil*.

The year introduced by *Numa* was that in uſe amongſt the *Grecians* before *Thales*, except one Day, as it conſiſted of 355 Days, and the Intercalations at firſt were made after the ſame manner as in *Greece*; ſo that the year uſed by the *Greeks* before *Thales*, and by the *Romans* from *N. Pompilius* to *Cæſar*, conſidered by itſelf, was the pure Lunar year; but conſider'd as uſed by both, with the Intercalations, Luniſolar, at leaſt amongſt the *Grecians*, who intercalated regularly; which, indeed, the *Romans* either through the Negligence or Perverſeneſs of their high Prieſt, did not; ſo that they may be juſtly ſaid to meaſure their year neither by Sun, Moon, or Stars, and conſequently

quently it can be reduced to no Order at all, any more than in *Romulus*'s Time.

The *Grecian* year therefore can hardly be called Luniſolar, and the *Roman* year has ſtill a leſs Title to that Name; ſince 'tis plain the former uſed the Lunar for common and only the Luniſolar, for that particular year in which they made their Interculations, and the latter by the Irregularity of their Intercalations render'd it ſo confuſed, that it is reduceable to none of the above claſſes of years.

The Ancients having made a Diſcovery of the Ecliptick Equinoxes and Solſtices, and reſolv'd upon meaſuring the Magnitude of the year by the apparent Motion of the Sun, that is, by the Number of Days he takes in moving from any one of the Equinoctial or Solſticial Points, until he return'd to the ſame again; it was natural for them to think of ſome proper Inſtrument to aſſiſt them in obſerving with Preciſion the Sun's Ingreſs into either of theſe Points, in order to determine the Magnitude of the Year with the greater Exactneſs. And tho' ſeveral concurring Circumſtances make it pretty evident, that both *Egyptian* and *Babylonian* Aſtronomers before *Thales* made Obſervations upon the Motions of the Sun; yet through the Injury of Time, their very Names are all loſt in the Hiſtory of Learning, except *Beroſus* alone. There are, indeed, ſeveral *Alexandrians* frequently mentioned

mentioned after the Death of *Alexander* the *Great*, ſuch as *Ariſtillus*, *Timochares*, *Eratoſtines*, and *Conen*, beſides others in different Countries ſuch as *Oenopides*, *Ariſtarchus*, *Helicon*, *Archimedes*, *Cleomedes*, *&c.* but little mention is made of the Inſtruments they uſed, except by *Hypparchus*, and theſe are deſcribed by *Ptolemy* in his Almagiſt. Theſe Inſtruments were called by the general Name of the Armillary Sphere, of which they had different Kinds, of theſe our Author mentions three; however, as the Sphere they uſed for obſerving the Sun's Ingreſs into the Equinoctial Points was much of the ſame Conſtruction with that uſed for the Solſtices, I ſhall only explain *Ptolemy*'s Deſcription of it, and that, by which they determin'd the Obliquity of the Eclipick and Equator.

The Sphere for obſerving the Sun's Entery into the Equinoxes conſiſted of two Circles of Braſs of a mean Magnitude, divided into 360 Degrees and each of theſe Degrees into 100 Parts, and ſo exactly fitted to one another, that the Concavity of the outer one, exactly correſponded to the Convexity of the innermoſt. Theſe they fixed perpendicular to the Horizon, in ſuch a manner that its Plane correſponded with the miridian; and this they effected by a Plummet fixed at the Vertex of the Circle: In this Poſition they fixed it to a Wall or Pillar erected for that Purpoſe,

with Nuts and Screws. The Plane of the other was at Right Angles with the Plane of this, and ſo fixed as to lie in the Plane of the Equator; it was of a conſiderable Breadth and Depth, ſo that on the Concave Side they had room to delineate the Ecliptick Signs, and therefore one half of it was elevated above the Plane of the Horizon by an Angle equal to the Compliment of the Latitude of the Place, and the other as much depreſſed. The Inſtrument being thus carefully fixed in this Poſition, it follows that while the Sun is moving from the Southern to the Northern Signs, or from ♓ to ♈, the Shadow of the upper Part of the Sphere, which the Day before coincided with that Part of the Concavity of the lower Sphere where the northern Signs are deſcribed, will now coincide with that Part of the Concavity where the Southern Signs are deſcribed.

On the other hand, when the Sun is moving from the Northern to the Southern Signs, or from ♍ to ♎ the Shadow will fall upon the Northern Part, where before it fell upon the Southern. But if the Sun be in the Equator, and conſequently in one of the Equinoctial Points, then will the Shadow of the upper Sphere, if contracted, exactly correſpond with that Line in the concave Side of the lower, which divides the Northern from the Southern Signs; or if not ſo much contracted as preciſely

ciſely to cover that Line only, then will the Limits be parallel to that Line, and on each Side equidiſtant from it, or that Line will be in the Centre of the Limits of the Shadow, and at the preciſe Time the Shadow happen'd to take that Poſition, they concluded the Sun was in one of the Equinoctial Points; and if at any Time it ſhould happen, that at the Evening, for Inſtance, on the 20th of *March*, the Shadow ſhould be North, and in the Morning at Sun-riſing South, then they concluded the Sun entered the Equinox in the Night betwixt the 20th and 21ſt, and the true time of his entering they calculated from the proportionable Diſtances the Shadow was found to be on the North and South Side of the Equinoctial line at the Sun's ſetting on the the 20th, and riſing on the 21ſt; and if theſe Diſtances were found to be exactly the ſame, they then coincided he entered the Equinox preciſely at 12 o'Clock at Night, on the 20th of *March*.

The only Difference betwixt the Sphere above explain'd, and that by which they obſerved the Solſtices, is,, that the Circle at Right Angles, to that which lies in the Plane of the Meridian, is made to correſpond with the Plane of the Ecliptick, and in all other Reſpects they are one and the ſame, and Obſervations are performed with it in the very ſame manner as with the other.

The Sphere us'd for taking the Inclination of the Ecliptick and Equator, according to *Ptolemy*'s Explanation, is a Circle of Braſs of a mean Magnitude divided into 360 Deg. and theſe Degrees into as many other Subdiviſions as the Magnitude of the Circle would admit of, and then another ſmaller Circle concentrick with it, ſo connected with it, that their Surfaces lay in the ſame Plane, the Convexity of the leſſer exactly correſponding to the Concavity of the greater, in ſuch a manner that it might freely turn round, their common Center ſtill keeping in the ſame Plane with the other Circle. Upon this ſmaller Circle are fix'd two Indices with Sights diametrically oppoſite to one another, in ſuch a manner that a Line drawn through them, paſſes thro' the common Center of both Circles. In the middle of theſe Indices two ſmall ſliding ones are inſerted, whoſe fiducial Lines point out the Degrees on the greater Circle.

This Inſtrument is fixed perpendicular to the Horizon, and in the Plane of the Meridian, in the ſame Manner as the Sphere above deſcribed. The Inſtrument being thus adjuſted, when the Sun came upon the Plane of this Circle, and conſequently in the Plane of the Miridian, the leſſer Circle was turn'd round until the Shadow of the Sight upon the Southern Index exactly cover'd that upon the Northern Index, and by that Means the fiducial

cial Line of the Southern Index pointed out the Sun's Diſtance from the Zenith in Degrees and Parts of a Degree. The Difference of theſe Zenith Diſtances, when the Sun was in the moſt northerly and moſt ſouthern Points of the Ecliptick gave double the Angle of the obliquity of the Ecliptick and Equator. And *Ptolemy* ſays, that by Obſervations made in this Manner he found the Difference between the two Zenith Diſtances to amount to 47 d. and ſomewhat more than two thirds of a Degree, which makes the Angle of Inclination of the Ecliptick and Equator, 23 deg. 51 m. 20 ſ. and this is the ſame that *Eratoſtenes* and *Hypparchus* made it, and always us'd in their Calculations.

It is highly probable, tho' we have no Account of the Nature of any of the Inſtruments uſed by thoſe who preceeded *Hypparchus*, that they were the very ſame as we have juſt now deſcribed. As this was the Method practiſed by all the Ancients in taking the Angle of Inclination of the Ecliptick and Equator, and the Sun's Ingreſs into the Equinoctial and Solſticial Points, and from thence determined the Magnitude of the Tropical Year, it muſt be allowed, that ſome of the Obſervations made by *Hypparchus* were perform'd with the greateſt Accuracy, eſpecially ſuch as related to the Magnitude of the Year. Since he made it to conſiſt of 365 days 5 hs.

55 m. and 12 ſ. which only differs from the moſt correct Obſervations ever made, even by the Moderns with all their Advantages, 6 m. 15 ſ. a Difference amazingly ſmall conſidering the vaſt Advantages we have over *Hypparchus*. For, beſides the Imperfections of his Sphere from the Shadow which cannot be ſo diſtinctly expreſs'd as to point out the Diviſions exactly on the Concave Side of the Equatorial Circle; his Obſervations were liable to other Errors ariſing from the Sun's Paralux, and Refraction, the laſt of theſe occaſions a conſiderable Error in his Altitude, and conſequently of his apparent Place in the Ecliptick. As Refraction makes the Sun of a greater Altitude than he really is, it anticipates the vernal, and retards the autumnal Equinox.

If, therefore, this ſhould happen in the Morning the Sun will appear to be twice in the Equenoctial Point on the ſame Day, once before he arrives at it, and again when he is near the Meridian and free from Refraction, which is the true time. And the ſame is to be underſtood, if the true time be Afternoon, and near 12 o'Clock, that is to ſay, once at the true Time, when he is near the Meridian, and free from Refraction, and again when he is near the weſtern Horizon, and affected by Refraction. This happened to *Hypparchus* himſelf, as *Ptolemy* obſerves, which made him

him conclude that the Sphere was a falſe Inſtrument, and that no Obſervations made by it could be depended upon. This Error *Hypparchus* found to be near ſix Hours, or one fourth Part of a Day, but could aſſign no other Cauſe for it then the Error ariſing from the Imperfection of the Inſtrument; but it is clearly demonſtrated by *Longomontanus*, *Bulialdus* and *Kepler*, that a greater Error than Six Hours may ariſe from Refraction, and beſides *Kepler* aſſerts that the ſame thing happened to *Tycho* in obſerving the Sun's Ingreſs into the Equinox by the armillary Sphere, the Shadow falling twice upon the Line that divides the northern from the ſouthern Side of the Ecliptick, and therefore if no Allowance was to be made for Refraction, the Sun would have been that Day twice in the ſame Place of the Equator, which is abſurd. However, tho' the Magnitude of the Year, from *Hypparchus*'s Obſervations, is nearer the Truth than any of his Predeceſſors, yet they are to be excuſed, and it is not a little ſurpriſing that ſo many of them came ſo near, conſidering the Imperfection of their Inſtruments, and no Allowance being made for Refraction.

Nay ſeveral of them did not differ from its true Magnitude above 11 min. and 3 ſec. as will more fully appear from the following Table, which contains the Magnitude of the Year, calculated by the moſt famous Aſtrono-

mers

mers before *Hypparchus*, and from him to the preſent time, where we may ſee at one View how near to the Truth theſe learned Men did approach.

Hermes Triſmigiſtus an *Egyptian* Aſtronomer, *anno ante Chriſtum* 1480, makes the ſolar Year to conſiſt of 365 days.

Ennius an *Egyptian*, *anno ante Ch.* 700, makes it 366 days.

Thales, the *Milleſian*, and the *Egyptian* Aſtronomers, cotemporary with him, make the Year 365 days, *anno ante Ch.* 620.

Oenepidus, of *Chios*, who liv'd, *anno ante Ch.* 560, makes it 365 days, 8 hours, and 57 min.

Harpalus, *ante Ch.* 520, makes it 365 days, 13 hours.

Democritus of *Abdera*, *ante Ch.* 456 Years, who ſtudied amongſt the *Chaldeans*, makes it 365 d. 6 h.

Meton, the Inventor of the Lunar Cycle, who, together with *Eutemon*, obſerv'd the Solſtices, and from thence determin'd the Magnitude of the Year, *ante Ch.* 422, makes it 365 d. 6 h. 18 m. 56 ſ. 51 th.

Aphrodius, an *Egyptian*, *ante Ch.* 400 years, makes it 365 d. 3 h.

Calippus Cyzicenes, *ante Ch.* 330 years, makes it 365 d. 6 h.

Ari-

	D.	H.	M.	S.	T.	F.	F.	S.
Ariſtarchus of *Samos*, *ante Ch.* 282, makes it	365.	6.	1.	16.	——	——	——	——
Archimedes, of *Sicily*, *ante Ch.* 266	365.	6.	——	——	——	——	——	——
Hypparchus the *Bithian*, *ante Ch.* 136	365.	5.	55.	16.	——	——	——	——
Gemius of *Rhods*, *ante Ch.* 83 years	365.	6.	——	——	——	——	——	——
Soſigines, who aſſiſted *Julius Cæſar*, *ante Ch.* 46 years	365.	6.	——	——	——	——	——	——
Iſacius, a *Jewiſh* Prieſt, *anno Ch.* 11	365.	5.	55.	12.	——	——	——	——
Ptolemy, *anno Ch.* 140, makes it	365.	5.	8.	——	——	——	——	——
Rabbi Adda, the *Jew*, who corrected the *Hebrew* Kalender, *anno Ch.* 340. makes it	365.	5.	55.	25.	26.	20.	——	——
Some Authors make this *Jew* the ſame with *Rabbi Samuel*; but that cannot be, for that *Rabbi* liv'd long before him, and who made the ſolar Year conſiſt of	365.	6.	——	——	——	——	——	——
Albategnius in *Aſſyria*, *anno Ch.* 879, makes it	365.	5.	46.	24.	——	——	——	——
The *Perſian* Aſtronomers, according to *Scaliger de Emendatione temparum*, and the two following Authors make the Year	365.	5.	48.	30.	——	——	——	——
Longimontanus in his *Aſtronomica Danica* makes it	365.	5.	48.	53.	20.	——	——	——
Bulialdus makes it	365.	5.	48.	59.	——	——	——	——

Yet neither of theſe Authors name the particular Aſtronomers among the *Perſians*, who thus calculated the Year, nor the Time the Magnitudes were adjuſted.

	D.	H.	M.	S.	T.	F.	F.	S.
In the Year 1250, *Alphonſus* K. of *Caſtile*, by the Aſſiſtance of *Arabian*, *Mooriſh*, and *Jewiſh* Aſtronomers, whom he had invited to his Court, computed the Year to be	365.	5.	49.	15.	58.	49.	16.	26.
This Magnitude of the Year, calculated by theſe Aſtronomers of *Alphonſus*, was followed in 1450, by *Georgius Perbachius*, an *Auſterian*, and Profeſſor of Mathematicks at *Ferrara* in *Italy* and *Vienna*; tho' both he and *Alphonſus* to abreviate this Calculation made it conſiſt of nearly	365.	5.	49.	16.	——	——	——	——
In the Year 1504, *Bernardus Waltherus* of *Nuremberge*, a Scholar of *Regimontanus* makes it	365.	5.	48.	50.	——	——	——	——
Copernicus, of *Warms*, in calculating the Magnitude of the tropical Year, divided it into great, mean, and ſmall. His great Year	375.	5.	55.	37.	40.	——	——	——
His mean Year is	365.	5.	49.	16.	23.	30.	——	——
His ſmall Year is	365.	5.	42.	55.	7.	——	——	——
In 1530, *Heironimius Cardan*, Profeſſor of Mathematicks at *Bononia*, makes it	365.	5.	48.	41.	——	——	——	——
In 1561, *Daniel Sanbech*, makes it	365.	5.	48.	41.	42.	33.	50.	10.
Ignatius Danter, of *Bononia*, in 1576, made the tropical Year	365.	5.	45.	36.	——	——	——	——
Maginus calculated the Year from the preutenic Tables, and divided into great, mean, and ſmall. His great Year conſiſted of	365.	5.	55.	53.	——	——	——	——

His

	D.	H.	M.	S.	T.	F.	F.	S.
His mean Year was	365.	5.	49.	16.	——			
His ſmall Year	365.	5.	42.	38.	——			
Meeſtlinus, from the ſame Tables makes it	365.	5.	49.	15.	46.	——		
In the Year 1582, when Pope *Gregory* rectify'd the Kalender, *Chriſtopherus Clavius*, of *Bamberg*, and *Alayſius Lelius*, of *Verona*, with the Advice of *Blancano*, at the Deſire of the Pope, calculated the Magnitude of Year, and found it to conſiſt of	365.	5.	49.	12.	——			
Much about the ſame time, *Tycho Brache*, the famous *Daniſh* Aſtronomer, found its Magnitude to be	365.	5.	48.	45.	——			
In the 1627, *John Kepler*, of *Wirtemberg*, Mathematician to the three Emperors.—— *Rodolphus*, and *Ferdinand* the Second, publiſhed the *Rodolphin* Tables, whereby he makes the Year	365,	5.	48.	57.	36.	——		
Chriſtianus Severini Longomontanus, a *Daniſh* Profeſſor of Mathematicks in the College of *Hafnia*, or *Copenhagen*, divides the Year into great, mean and ſmall, after the Example of *Copernicus*. His great Year he makes	365.	5.	51.	29.	12.	——		
His mean is	365.	5.	48.	55.	——			
His ſmall is	365.	5.	46.	20.	48.	——		
David Organus, of *Sileſia*, Profeſſor of Mathematicks at *Frankfort*, in his *Ephemerides* of 59 Years, or from the Year 1595 to 1654 divides the tropical Year into great, mean and ſmall. His great Year is	365.	5.	56.	53.	——			

	D.	H.	M.	S.	T.	F.	F.	S.
His mean Year is	365.	5.	49.	15.	——	——	——	——
His ſmall Year is	365.	5.	42.	38.	——	——	——	——
Galifredus Vendelinus, a *Dutchman*, in 1644, makes it	365.	5.	49.	5.	27.	16.	——	——
Iſmael Bulialdus, in 1645, makes it	365.	5.	49.	4.	21.	3.	——	——
Johannes Baptiſta, an *Italian* of *Bononia*, 1651, makes it	365.	5.	48.	48.	——	——	——	——
Phillippus Lansbergius, of *Ghent*, in his *Tabulæ motuum perpetuæ*, printed 1682, makes the tropical Year	365.	5.	48.	57.	2.	22.	4.	——
Dionyſius Petavius, *De ratione Tempore*, makes it	365.	5.	49.	——	——	——	——	——
Doctor *Gregory*, in his Aſtronomy, makes it	365.	5.	49.	——	——	——	——	——
Caſſini, Dr. *Keil*, and others	365.	5.	49.	57.	——	——	——	——

The Inaccuracy of the Inſtruments with which the Ancients made their Obſervations, the Incertainty of the true Poſition of the Shadow, and the great Errors that muſt neceſſarily ariſe from the miſtaking its Poſition, when the Sun is low and affected with Refraction, whereof they were intirely ignorant, is the Foundation of all their Errors relating to the Magnitude of their Year.

It is not at all ſurprizing, that the Ancients, before *Ptolemy*'s Time, differ'd about the Magnitude of the ſolar Year, ſince a few Minutes of Refraction will occaſion ſuch odds, but on the contrary, it is rather aſtoniſhing that the Difference ſhould be ſo ſmall, and

that

that ſo many of them agree in one and the ſame Magnitude; for *Democritus*, *Callippus*, *Archimedes*, *Gemius*, *Soſigenes* and *Rabbi Samuel*, all agree in making the Magnitude of the ſolar Year to conſiſt of 365 Days 6 Hours, tho' they lived in different Ages; and all theſe came within eleven Minutes and three Seconds of the Truth, at leaſt of the moſt accurate Obſervations ever yet made by the Moderns with all their Advantages.

It appears from the foregoing Table, by comparing the Magnitude of the Year calculated by *Hypparchus* with the Calculations of *Iſaacus Argyrus* and *Rabbi Adda*, that betwixt *Hypparchus* and *Argyrus* there is only 2 Minutes and 24 Seconds, and betwixt *Hypparchus* and *Adda* there is only 13 ſec. 26 th. 24 fo. though they liv'd 476 Years diſtant from one another, which is almoſt incredible conſidering the Inaccuracy of their Inſtruments. But it is no leſs ſurpriſing when we compare the Obſervations made by the Moderns ſince *Tycho*'s Time, to find that they differ at leaſt from one another as much as the Antients, notwithſtanding their ſuperior Advantages from the Knowledge of the Paralaxes, and Refraction, and above all, their being furniſhed with Inſtruments of moſt exact conſtruction, founded upon the juſteſt Principles, and executed by the moſt exquiſite Workmen; yet betwixt the

the mean Year of *Origanus*, Profeſſor of Mathematicks at *Frankfort*, calculated 1593, and the Obſervations made by *Caſſini*, of the Royal Academy at *Paris*, which is without diſpute the moſt correct, there is no leſs than 18 ſec. which is 5 more than between *Hypparchus* and *Rabbi Adda*. Mr. *Flamſtead*, our Countryman, agrees exactly with *Caſſini*, in his Calculation of the Year.

There are, indeed, others that have come a good deal nearer to *Caſſini* and *Flamſtead*, particularly *Lansberg*, who only differs from *Caſſini* and *Flamſtead*, 2 th. 22 ſo. and 4 fif. But with theſe ſuperior Advantages one ſecond of Difference is more than a Minute to the Antients in Proportion to the Diſadvantages they labour'd under. And even the Obſervations of the *Perſians* as appears from *Longomontanus* and *Bulialdus*, are more correct than the Obſervations of the modern *Europeans*, for according to *Longomontanus* their Year is only 3 ſec. and 40 th. leſs than *Caſſini*, and according to *Bulialdus* it is only 2 ſec. more. But neither of theſe Authors informs us at what Time theſe Calculations were made, nor ſo much as the Names of thoſe who made them: However, as *Longomontanus* ſucceeded to *Tycho*, we may conclude they were at leaſt antecedent to *Tycho*'s Time. And hence it plainly appears, that more

more accurate Obſervations may be made with bad Inſtruments, by Men of great Abilities, than with the moſt complete by Men of inferior Parts: What might have been expected then from the Obſervations of *Hypparchus* and his Succeſſors, had they been aſſiſted with ſuch correct Inſtruments, together with the Knowledge of the Errors that ariſe from Refraction, *&c.* Advantages the Moderns now enjoy, and are in the Uſe of practiſing daily.

Having thus far given a ſhort Hiſtory of the Magnitude of the Year, from the earlieſt Ages down to our own Time; we ſhall in the next proceed to conſider the Errors of the *Julian* and *Gregorian* Periods, and in the Concluſion lay down a Method for correcting them and ſetting the true Time of *Eaſter*, upon which all the other moveable Feaſts depend.

It has been already obſerved, that *Julius Cæſar* brought over from *Egypt*, *Saſigenes*, the moſt famous Aſtronomer of that Age, to ſettle the true Magnitude of the tropical Year, who agreeing with *Archimedes* and *Callippus*, *&c.* made it to conſiſt of 365 days, 6 hours. But as the true Magnitude, from the beſt and moſt accurate Obſervations, is found to be 365 days, 5 hours, 48 minutes, and 57 ſeconds, as we have already remark'd; ſo that the

the *Julian* Year exceeds the true tropical Year by 11 minutes, and 3 ſec. or 663 ſec. and conſequently 100 *Julian* Years will exceed 100 true Years 100 times 663 ſec. that is 66300 ſec. which being reduced to Hours, we find to be preciſely 18 hours, and 25 minutes.

As one Day conſiſts of 86400 ſec. and each *Julian* Year exceeding each true Year by 663 ſec. the Proportion is, as 668 ſec. is to 86400, ſo is one Year to the Number of *Julian* Years that exceeds the ſame Number of true Years by one whole Day, and this fourth Proportional being 130 Years, and 31674 one hundred thouſand Parts of a Year as may be ſeen in the Operation.

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Therefore it follows, that 130 *Julian* Years, and 31674, One hundred thouſand Parts of a *Julian* Year will exceed the ſame Number of true Years by a whole Day.

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Wherefore, if in that Year the Council of *Nice* was held, the Sun enter'd the vernal Equinox upon the 21ſt Day of *March*, agreeable to the Obſervations of *Euſebius* of *Ceſarea*, and other *Alexandrian* Aſtronomers, who were employ'd by the Council for that Purpoſe; therefore, in the Space of 130 Years, and 31674, One hundred thouſand Parts of a Year, after it the *Julian* Year will then have exceeded the true Year by one whole Day: And hence, at the End of that Time when the tropical Year was completed, the *Julian* Year wanted one whole Day to complete it; conſequently, by the *Julian* Account, the Sun muſt have enter'd the vernal Equinox one Day ſooner, than he did at the Council of *Nice*; that is, he enter'd it upon the 20 *March*.

Again, in ten Times the above-mentioned Number of Years after the Council of *Nice*;

that is, 1303 *Julian* Years, and 1674 Ten thouſand Parts of a Year, the *Julian* did exceed the true Year ten whole Days; and therefore, in that 1303d Year after the Council of *Nice*, the Sun enter'd the vernal Equinox upon the 11th Day of *March*: And hence it clearly follows, that, by meaſuring the Year by the *Julian* Method, the Sun's Ingreſs into the vernal Equinox muſt go backward towards the Beginning of the Year.

And, ſince between the Council of *Nice*, which was held in the Year 325, and the Year 1582, when Pope *Gregory* rectified the Kalendar, there are 1257 Years, which only wants 46 of the above Period, 1303; *viz.* the Number of *Julian* Years, that exceed the ſame Number of true Years, by ten whole Days; therefore the Sun, in the Year 1582, muſt have enter'd the vernal Equinox, nearly ten Days ſooner than at the Council of *Nice*; or, in other Words, more particularly, the Sun muſt have enter'd the vernal Equinox the 11th of *March* 1582, 8 Hours, 28 Minutes, and 18″; that is, the 18th Second of the the 29th Minute of the 9th Hour of the Day following, or 12th Day of *March*.

It has been the conſtant Practice of the Chriſtian Church, to celebrate the Feaſt of *Eaſter* upon the firſt *Sunday* after the firſt Full-Moon that happened after the vernal Equi-

Equinox; and, if that Full-Moon ſhould fall upon a *Sunday*, then the *Sunday* following is made *Eaſter-Day*: But, by the *Julian* Method of meaſuring the tropical Year, the Equinoxes go backward; which renders it difficult, at leaſt to the greateſt Part of Mankind, to determine the true Time the primitive Chriſtians ſolemnized this Feſtival; and, for that Reaſon, Pope *Gregory* reſolved to rectify the Kalendar ſo, as the Feſtivals might happen about the ſame Time as they did at the Council of *Nice*.

The eaſieſt Way to effect this, he imagined, would be carefully to obſerve the preciſe Time of the Day the Sun enter'd the vernal Equinox that Year, *viz.* 1582, and call that Day the ſame nominal Day he enter'd it, in 325, the Year in which the Council of *Nice* was held. In order to effect the firſt Point, he order'd *Clavius*, *Lelius*, and other able Aſtronomers, accurately to obſerve the Sun's Ingreſs into the vernal Equinox; but either from the Badneſs of their Inſtruments, or Inaccuracy of the Obſervers, there happened a great Difference amongſt them about the true Time he enter'd the Equinoctial Point, as we are informed by *Clavius*'s Commentaries on *Johannes de Sacraboſco*, *Bulialdus*, and others. And therefore, out of all theſe, Pope *Gregory* choſe the Mean, allowing that the Sun that

Year enter'd the vernal Equinox upon the 11th Day of *March*. According to this Calculation, there is ten Days of Difference between his Entery that Year, and the Year 325, when the Council of *Nice* was held; which he order'd to be ſtruck out of the Kalendar, by calling the 5th Day of *October* the 15th. This was *Gregory*'s firſt Step towards a Reformation of the Kalendar. His next was to conſider the Magnitude of the Year; and, finding that the Difference betwixt the Aſtronomers employed by him, and thoſe employed by *Julius Cæſar*, was 10 Minutes and 48 Seconds, or 648 Thirds, he concluded, that 133 Years, and a third Part of a Year, according to the *Julian* Method of Reckoning, would exceed the ſame Number of true Years by one whole Day; and thus 400 *Julian* Years would exceed the ſame Number of true Years by three whole Days, preciſely, without any Fraction. The Pope, truſting to this Calculation, concluded, and, indeed, with great Reaſon, had it been exact, that if three whole Days were taken away from every 400 Years by the *Julian* Account, the Error, ariſing from the Anticipation of the Equinox, would be rectified, with the greateſt Exactneſs, for ever.

This was the Reaſon that made *Clavius* aſſert, that Time, by this Correction, would be for

for ever truely meaſured, without either Loſs or Gain of one Second; and that, in each Period of 400 Years, the Sun would enter the vernal Equinox, not only on the ſame Day of the Month, but the ſame Hour, Minute, Second, *&c.* of that Day.

This Concluſion of *Clavius* was founded upon the Hypotheſis, that the true Magnitude of the tropical Year was 365 Days, 5 Hours, 49 Minutes, and 12 Seconds; and, if that had been true, his Concluſion was certainly juſt. But Obſervations cotemporary with *Clavius*, gave Birth to ſeveral Diſputes about the Magnitude of the Year, as they differed from his Calculations, and, conſequently, diſſapproved of the Kalendar founded upon them; as may be ſeen, at large, in his Apology for the *Gregorian* Kalendar, and in *Ricioli*, &c. and, indeed, both Obſervations and Experience have ſince proved, that theſe Objections were well founded, as we ſhall more particularly examine hereafter. But to return to *Gregory*'s Correction:

Since he thought, that if three Days were taken away from each Period of 400 Years, Time would, by that means, be for ever truely meaſured; and, as it was of no Conſequence from what particular Year theſe three Days were taken, he ordered, that each of the firſt 300 Years which, by the *Julian* Method, would

would be Leap Years, consisting of 366 Days, should be Common Years, consisting of 365 Days, and that each 400th Year should be a Leap Year, consisting of 366 Days; and hence, 1700, 1800, and 1900 Years, should be Common Years, of 365 Days; and that 2000 should be a Leap Year, consisting of 366 Days; as also, that 2100, 2200, 2300, should be reckoned Common Years, and 2400 a Leap Year: That is, in general, that all those complete Hundreds, whereof the significant Figures, exclusive of the Cyphers, that are divisible by 4, are made Leap Years; but all these complete Hundreds, whose significant Figures, exclusive of the Cyphers, that are not divisible by 4, are Common Years; and hence, 3200 and 4800, are Leap Years; because the significant Figures 32 and 48, exclusive of the Cyphers, are divisible by 4; but 2600, 3000, 3800, are Common Years; because their significant Figure 26, 3, and 38, are not divisible by 4.

All other Years, except the complete Hundreds, he ordered still to be reckoned after the same manner as *Julius Cæsar* had done; that is, every fourth Year a Leap Year, and all the rest Common Years: So that any Number whatever, if divisible by 4, is a Leap Year, but if not divisible by 4, a Common Year. This is what we call the *Gregorian*, or *New Stile*;

Stile; and the only material Difference betwixt it and the *Old Stile*, after ſtriking the ten Days out of the Kalendar, in order to make the Feſtivals happen upon the ſame Days they did at the Council of *Nice*, is, that all complete Hundreds of Years are Leap Years, by the *Julian* Method of Reckoning; and by the *Gregorian* Method, only every fourth complete Hundredth Year is reckoned a Leap Year, and all other complete Hundredth Years are only Common Years, as we have above obſerved, and, in all other Reſpects, they are the ſame.

If the Magnitude of the Year calculated by *Clavius*, *Lelius*, &c. had been the true Magnitude of the Year, it is plain, from what has been already obſerved, that the Corrections made on the Kalendar, by *Gregory*, would have been ſo completely exact, as never to have incurred an Error of a Second to the End of infinite Ages; but, as the Magnitude of *Gregory*'s Year was 365 Days, 5 Hours, 49 Minutes, and 12 Seconds; and the Magnitude of the true Year is now, from the moſt accurate Obſervations, found to be 365 Days, 5 Hours, 48 Minutes, and 57 Seconds: So that the *Julian* Year, inſtead of exceeding the true Year by 10′ and 48″, exceeds it 11′ and 3″, and 130 *Julian* Years, and 31674, One hundred thouſand Parts of a Year, and not 133 Years

Years and one Third of a Year, exceeds the ſame Number of true Years by one whole Day.

Upon this Hypotheſis, wherein, I think, we may venture to acquieſce, we ſhall compare the true Meaſure of Time, to *Gregory*'s Method, and clearly point out the Errors that neceſſarily follows from reckoning after it.

As *Gregory* ordered, that the firſt Three hundred complete Years ſhould be Common Years, each conſiſting of 365 Days, inſtead of 366, which, by the *Julian* Account, they ſhould have conſiſted of; and as, by the *Julian* Account, there is only gained on true Time 66300″, or 18 Hours and 25 Minutes, in a Hundred *Julian* Years; and 24 Hours, or one whole Day, being ſubtracted by the *Gregorian* Method, it is evident there is taken away 20100″, or 5 Hours and 35′ more than ought to be: So that we ſee, there is taken away, in the firſt 300 Years, 60300″ more than the Truth, which amounts to 16 Hours and 45′; and conſequently, the *Gregorians*, at the End of 300 Years, will, by this means, have juſt loſt that much upon true Time. But, as in the *Julian* Account there is gained the fourth Hundredth Year 66300 Seconds, or 18 Hours and 25 Minutes, and in the preceeding 300 Years there was loſt 16 Hours and 25 Minutes; and theſe two Errors being of a contrary Na-

Natures, but not equal to one another, the Gain being one Hour and 40 Minutes more than the Loſs, they will not deſtroy one another; ſo that there will be gained upon true Time, at the End of the fourth Hundredth Year, 6000 Seconds, or one Hour and 40 Minutes: And hence there will be a ſucceſſive Gain of one Hour and 40 Minutes, or 6000″, at the End of each ſubſequent Four hundredth Year.

Therefore, as 6000″ is to 86400″, or one whole Day, ſo is 400 Years to a fourth Proportional, which will be the Number of Years in which one whole Day is gained, by *Gregory*'s Method; and that, as appears by the Calculation, is juſt 5760 complete Years, without any Fraction.

As *Gregory*'s Error is of the ſame kind with that incurr'd by *Julius Cæſar*, the Equinoxes will ſtill go backwards, as before; ſo that *Gregory*'s Method, compared to *Cæſar*'s, is only a nearer Approximation to the true Meaſure of Time.

6000″ : 86400 :: 400 :

400

6000)34560|000(5760

30

45

42

36

36

0

The Correction of this Error, incurr'd by *Gregory*, evidently ſhews itſelf; for ſince, from the above Calculation, the fourth Pro-

portional is preciſely 5760, without a Fraction; and that being the Number of Years in which one whole Day is gained, and that Number, at the ſame time, being a Leap Year, both by *Gregory* and *Cæſar*'s Method, becauſe the ſignificant Figures in this Number are diviſible by Four; therefore, if every 5760th Year be accounted a Common Year, then will *Gregory*'s Error be corrected, and Time, for ever, truely meaſured: And, in each Period of 5760 Years reckoned in this manner, the Sun will enter the vernal Equinox not only on the ſame Day of the Month, but on the ſame Hour of the Day, and on the ſame Minute, Second, Third, *&c.* of that Hour; that is, on the ſame Point of Duration of that Hour, as *Clavius* had before obſerved of *Gregory*'s Correction. But as this Error of *Clavius* aroſe from his aſſigning too great a Meaſure for the tropical Year; if future Obſervations be made with more Care and Accuracy than thoſe from whence this Magnitude of the Year is taken, (which I very much queſtion) then will the Calculation fall a little ſhort of the Truth, though not near ſo much as *Gregory*'s; for, ſuppoſe 2″ of an Error, in that Event, there can neither be gained nor loſt on true Time above a whole Day, in leſs than 43200 Years, when there will be preciſely one Day gained, if it ſhould be

be found 2 Seconds more; or there will be one Day loſt, if 2 Seconds leſs: That is, if this Year ſhould be found 2 Seconds more than the Truth, then will it conſiſt of 365 Days, 5 Hours, 48 Minutes, and 55 Seconds; ſo that it will gain upon true Time 2 Seconds every Year, and conſequently will gain exactly one whole Day in 43200 Years. Therefore, if, beſides the above Correction of making every 5760th Year a Common Year, each 43200th Year, which is a Leap Year, both by the *Julian* and *Gregorian* Method of Reckoning; becauſe it is a complete Period of Hundreds, whoſe ſignificant Figures 432 are diviſible by 4, be likewiſe made a Common Year, conſiſting of 365 Days, then will Time be meaſured with the ſame Degree of Exactneſs, as above-mentioned: And, on the contrary, ſuppoſe the true Year to conſiſt of 365 Days, 5 Hours, 48 Minutes, and 59 Seconds, or 2 Seconds more than what we have computed from, then will be loſt 2 Seconds each Year, and one whole Day in the ſame Period of 43200: So that if this Year, as we have already obſerved is a Leap Year, be made a Common Year, conſiſting of 367 Days, and that extraordinary Day may be intercalated in the ſame manner as *Julius Cæſar* intercalated his Day, *viz.* on the Sixth of the Kalends of *March*, the Error will be corrected, as before.

This

This points out a plain Rule, by which the Kalendar may be corrected to the greateſt Degree of Perfection by Poſterity, according to the true Magnitude of the Year, that may be diſcovered by accurate Obſervers.

Had a Clauſe been inſerted in the Bill for altering the Stile, That each 5760th Year, which, by the *Gregorian* Method, is a Leap Year, ſhould be a Common Year; ſince, by that means, Time would not only have been meaſured with the utmoſt Exactneſs, but an Honour reflected on the *Britiſh* Senate, and Nation in general, as being the firſt People who introduced the Method of correcting Time to the higheſt Degree of Perfection. The Addition of this Clauſe could not, for many Generations, affect the Common Argument; *viz.* That it is of great Advantage to Trade in general, that all Nations ſhould reckon Time after the ſame manner, which, perhaps, was the true Cauſe of our altering the Stile; becauſe moſt Nations of *Europe* reckon by the *Gregorian*, as we ſhould only have differed from it one ſingle Day in 5760 Years; and beſides, there is a great Probability, that all *Europe* would have followed our Example, and corrected their Account of Time according to our Model.

F I N I S.